# A REVIEW OF THE A WESTERN AREA POWER AUTHORITY REPORT ON AN "ECONOMIC ANALYSIS OF POWER SYSTEM IMPACTS OF GLEN CANYON DAM LONG-TERM EXPERIMENTAL OPTIONS"


By

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and
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Science Advisors


OCTOBER, 2006

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## INTRODUCTION

In 2005 the Secretary Designee and the Adaptive Management Program (AMP) requested that the Grand Canyon Monitoring and Research Center (GCMRC) and Technical Work Group (TWG) develop recommendations for a Long Term Experimental Plan. A Science Planning Group (SPG), structured by the GCMRC and TWG, developed several experimental plan options over 12 months in 2005/2006. These were then reduced to three options for comparison to the current Record of Decision (ROD) for operations at Glen Canyon Dam, referred to as Modified Low Fluctuating Flows (MLFF).

To understand more fully how each of the three options might impact Colorado River Ecosystem (CRE) recourses, the SPG requested that Statements of Work (SOW) and two resource impact assessments be developed. The SPG appointed a Task Team to accomplish the assessments.

A Statement of Work and Assessment of Economic Impacts on Hydropower Resources has been conducted by WAPA. A Statement of Work and an Assessment of impacts on the Biophysical and Socio-Cultural

[1] In 2004 and 2005 the Science Advisors disciplines were reduced from 12 to 8. Economic discipline expertise on the Science Advisors is now represented only in the Executive Secretary, Dr. Garrett. As such, four additional external reviewers were requested to assist with this project review.

Resources has been conducted by GCMRC program managers and scientists.

The SPG realized that significant uncertainty would exist in developing these assessments. As such, the assessments are, in major part, to be considered preliminary.

Assistance in developing external reviews of the statements of work and assessments was requested of the Science Advisors (SAs) and their Executive Secretary. Four reviewers external to the Science Advisors have provided review input to the Hydropower Economics Statement of Work and the Hydropower Economic Assessment Report. The AMP Science Advisors provided review of the Biophysical and Socio-Cultural Resource Impact Statement of Work and the final assessment report.

A review of the Statement of Work for the "Economic Analysis of Power System Impacts of Glen Canyon Dam Long-Term Experimental Options" was completed in September, 2006. The report was filed with the Task Team, GCMRC and WAPA, who revised their assessment report based on the review (Appendix A).

A fourth experimental option was presented in the final phases of this assessment, requiring a TWG conference call for resolve. In the call, another option previously discussed by the SPG was also proposed for consideration. Both options were debated in a TWG conference call of October 6, 2006. After discussions, a vote was called on the two proposed options. The new option was approved for evaluation by GCMRC, and the option previously considered by the SPG was rejected from evaluation.

GCMRC developed comparable descriptions for each of the four options and summarized the attributes of each option, which are provided in Table 1.

The economic impact assessment of the four options, completed by WAPA was presented for review to four hydropower economists by the SA Executive Secretary on October 13, 2006, as scheduled. Five workdays were

allotted to complete these reviews to conform to scheduled reviews by TWG and AMWG.

## REVIEW OF THE ECONOMIC ASSESSMENT SOW

The following hydropower economists reviewed the research methods for the economic assessment in September, 2006 and found the methods presented, although abbreviated, to represent reasonable approaches for these types of analysis (Appendix A).

- J. Lon Carlson; Illinois State University
- John Fazio; Northwest Power and Conservation Council
- Dave Harpman; Bureau of Reclamation
- Tom Veleska; Argonne National Laboratory

One of the reviewers could not provide comments on the assessment report due to an assignment in Africa.

**Table 1.** Summary of flow and nonflow components of the four experimental options under consideration by the Glen Canyon Dam Adaptive Management Program. BASE operations (modified low fluctuating flow regime) are provided for comparison. Each option is described as it would be implemented under an annual release of 8.23 million acre-feet.

| | Flow/Nonflow Treatment | BASE operations | Option A | Option A Variation | Option B | Option C |
|---|---|---|---|---|---|---|
| Flow | Increased daily flow fluctuations | No | Yes (increased by 50% to 66% in winter months and by 25% in summer months) | Yes (increased by 25% to 66% in all months except April and May) | No | Yes (increased by 50% to 66% in winter months) |
| Flow | Stable flows | No | No | No | Yes, (tests of 4, 8, and 12 months) | Yes, (September through October) |
| Flow | Beach/habitat-building flows | Possible, but only under hydrologic triggers | Yes, as tests under sediment input triggering | Yes, as tests under sediment input triggering | Yes, as tests under sediment input triggering | Yes, as tests under sediment input triggering |
| Flow | Alternative ramping rates | No | Yes (hourly down ramping rate increased 100% in all months) | Yes (hourly down ramping rate increased 100% in Apr–Oct and 167% in Nov–Mar ) | No | Yes (hourly down ramping rate increased by 100% in Nov–Jul only) |
| Nonflow | Temperature control device | No | Yes | Yes | Yes | Yes, 2 units assumed |
| Nonflow | Control of nonnative coldwater fish | No | Yes, as needed | Yes, as needed | Yes, as needed | Yes |
| Nonflow | Control of nonnative warmwater Fish | No | Yes, as needed, with R&D starting in 2007 | Yes, as needed, with R&D starting in 2007 | Yes, as needed, with R&D starting in 2007 | Yes, with R&D starting 2007 |
| Nonflow | Humpback chub disease/parasite research | No | Yes | Yes | Yes | Yes, with R&D starting 2008 |
| Nonflow | HBC translocation | No | Yes | Yes | No | [1]Yes |
| Nonflow | Humpback chub refuge(s) | No | Yes | Yes | Possibly | [1]Yes |
| Nonflow | HBC population augmentation planning | No | Yes, Planning efforts toward implementation, as needed | Yes, Planning efforts toward implementation, as needed | No | [1]Yes, planning phase |
| Flow and Nonflow | [2]Mini experiments | No | Yes | Yes | Yes | [1]Yes |
| Experimental Design | | Not applicable | Reverse Titration | Reverse Titration | Factorial | Forward Titration |

NOTE: 1) For Option C: Ancillary projects not considered part of the main experiment; implementation decision includes consideration of confounding the main experiment. 2) Mini experiments are short-term field experiments that do not confound main experimental treatment

## REVIEW CHARGE FOR ECONOMIC ASSESSMENT REPORT

All reviews of documents requested of the GCD AMP Science advisors are preceded by a review charge from the Executive Secretary. Generally the charge is to respond to specific questions.

This review of projected hydropower economic resource impacts from four differing experimental options responds to five science questions as follows:

1. Were the methodologies and assumptions for this assessment sufficiently articulated for you to fully understand the analysis and the validity of the findings presented?
2. Do you feel that the analysis is sufficiently adequate to evaluate the differences in hydropower economic impacts that will result from implementation of the four differing experimental flow options?
3. Can you identify any clear errors in application of models, assumptions, economic or technical knowledge in this analysis? If so do they significantly affect the outcome of the analysis, i.e. change the conclusions of the report?
4. Can you identify any clear bias in outcomes caused by use of inputs, models, economic knowledge, assumptions, etc? If so, do you feel they affect the outcomes significantly, and how?
5. Even if this analysis is acceptable, there is more than one way that it could have been conducted. What recommendations would you give to improve upon this type of analysis in the future?

## FINDINGS OF THE REVIEW

Having the reviewers evaluate the methods for this analysis prior to conducting the assessment significantly benefited the review of the final report. All three reviewers of both documents (one economist could not conduct the report review) were able to spend more time on evaluation of how the methods applied affected outcomes.

The following findings of the review are primarily developed responses to the above five questions. Additional responses are also included.

**Were Methods and Assumptions Specified Effectively?**

The general finding of the reviewers was that methods and assumptions were adequately specified. Two of the three reviewers have working knowledge of all models used in this analysis, and have both conducted and/or reviewed similar analysis on this or other facilities. Methods used for developing data for analysis, determining costs, prices, net present values, expected values etc. are standard economic assessment practices.

**Specific Reviewer Comments are as Follows:**

- By and large, the methods and assumptions are reasonably well stated. The report is clearly a rough draft and requires a substantial amount of editing to improve clarity and readability. Additional material also needs to be added. In particular, what tends to be missing at certain points is adequate *justification* for assumptions made. In my list of specific comments I note several instances where this is the case. In order to enhance the credibility of the study's findings, it is important to establish that the assumptions made are defensible. If that justification/defense is missing, it leaves the estimated impacts more vulnerable to attack.
- Given the quick turn around time that was needed to complete the analysis, it is adequate if relative option rankings and ball park numbers are required. If the absolute economic values are key to the decision making process, more information about the analysis and a further review of the inputs and methods may be warranted.
- The authors also need to do a better job of explaining why this can be viewed as an economic (as opposed to a financial) analysis, how the GT Max model works and how the beach habitat building flow analysis was conducted.

- The ranking of the options in terms of economic value appear to be correct with Option A Var the highest and Option B Var the lowest.

- The authors should talk more about the attempt to measure opportunity costs incurred or foregone (avoided), as a result of implementing each GCD option.
- The general magnitude of the options also appear to be in the ballpark, but my gut reaction is that the positive economic options are underestimated and the negative options should have a larger negative impact (i.e., too small of a range). However, it is difficult to tell without more information.
- Overall I found the draft to be very readable and the methods to be appropriate. I was a little confused regarding the use of market prices vs. deferred or accelerated new resource acquisition. I'm still not sure whether you are suggesting an alternative approach to estimating the cost or if you are just using the capital cost of new resources to assess the capacity costs. In the Northwest we have used the "market" approach for the last decade or so as a surrogate to a more detailed analysis, which would look at changes in resource acquisition over time. The later implies more of a production costing approach to the economic analysis, which would be more difficult and probably not necessary for this type of screening study.
- I have a little concern regarding the capacity cost/benefit analysis. My biggest question is whether all capacity reductions would be replaced or if all capacity surpluses would be sold on the market. Does the capacity market get saturated quicker than the energy market? More research in this area would be helpful.
- I also believe the expected net present value and expected levelized cost are the best outputs to report. For one, the expected levelized cost is a more realistic assessment of the average annual cost over a

period of years and can be readily compared to other levelized costs, such as capital expenditures.

- I did not like the fact that loss/gain of economic value is based on the difference in capacity range or load following capability (Max-Min generation). It should have been based on a comparison of estimated capacity levels.
- Using hourly market price patterns in GTMax instead of flat on-peak and off-peak prices would have yielded better GC generation patterns and capacity estimates. These points in combination most likely contributed to a lower range of impacts than I expected.
- It seems to me that there will be some non-power consequences of the options. Each option may affect fish and wildlife, recreation or other uses of the facility in different ways. Those types of impacts should be mentioned, even if assessing a cost for them may be impossible.
- It generally takes several years to get permitting for a plant to be built. An alternative approach is to estimate the market value of capacity and use this as a surrogate for the economic value of lost capacity. The market value should vary by month and/or season whereby summer and winter capacity is more valuable than spring and summer capacity. (pg 5, paragraph 3).
- The previous sentence is probably worded incorrectly – generation is less than ROD limits? (pg 6, paragraph 4).
- This appears to be reasonable as long as this is true for experimental options. (pg 7, paragraph 2).
- First simplifying assumption. Can the authors justify this assumption by assuming direct pass through of any changes in costs to CRSP customers? (pg 4).
- The fourth and fifth bullets in the simplifying assumptions section (begins on pg. 4) are really specific examples/illustrations of the third bullet. The material should be reorganized to reflect this. (pg 6).

- "No drop" assumption. How does this assumption affect the estimated impact of each option evaluated in the report, i.e., does the no-drop assumption lead to a systematic increase or decrease in the estimated impact of each option? More generally, why was the assumption made? (pg 6).
- This sentence seems to contradict the preceding one. Are resources acquired in normal unit sizes (or blocks) or are they acquired to the exact magnitude of the need? (pg 5, paragraph 4).
- What types of new resources are assumed for this analysis? Are they gas-fired resources, other types or a mix? (pg 6, paragraph 2).
- I don't understand this sentence. Additional generation or capacity is not sold on the spot market? What does "postponed" mean in this case? (pg 6, paragraph 3).
- What happens if the market is saturated in the off peak hours? Are there minimum flow constraints that may prevent this equal swap between the on-peak and off-peak hours? Are we to assume that in no option is the average daily outflow changed? Are the changes large enough to affect the head, which would affect the efficiency of power production? (pg 6, paragraph 4).
- Does it perform an hourly dispatch over the 168 hours of one week? (pg 8, paragraph 3).
- I assume that this includes ramp up and down constraints. (pg 8, paragraph 4).
- If new resources are built, does GT MAX determine their dispatch or is that input by the user? (pg 10, paragraph 1).
- The GT Max Model. This section needs clarification. My assumption is the objective function is maximization of the difference between Western's total revenues and the total costs of meeting its contractual commitments, but it's not clear from the discussion whether my assumption is correct. (pg 7).

- Last paragraph and continuing on to page 9. Assuming CRSP customers are served by all generating units simultaneously, how does isolation of GCD affect estimated impacts, i.e., if the other plants were included in the analysis is it likely that some amount of substitution among plants would take place that would, to some extent, mitigate estimated impacts, or is it more reasonable to assume that operations at the other plants would be unaffected by the proposed changes at GCD that are being analyzed? (pg 8).
- Do any of the options affect monthly releases or are they assumed to always be the same. If monthly water releases do differ, tables of other options should be provided, since water is more valuable in peak months (July & August) relative to off-peak months (e.g., Oct). (pg 12).
- If this document is a standalone report, it should include a brief description/table of all other options. (pg 14).
- Modeling CRSP/IP facilities other than Glen Canyon in this simplified manner is OK as long as the options being studied do not affect their operations. If operations are affected, more details should be included in the model. (pg 15, paragraph 3).
- Customer schedules over the past year were at a low level, since hydropower resources are very dry. These loads are therefore appropriate to use in the 8.23 MAF years. However, in wetter years, customers would have a larger AHP and therefore request more energy. (pg 15, paragraph 2).
- First of all, the authors need to be specific about the type of information they obtained from Prebon Energy. It would appear that there is a single on-peak price and single off-peak price for each month. For each month, the estimated price paid, by hour, was then adjusted to reflect the level of demand by indexing demand to maximum demand during the month. There are two important assumptions being made here: (1) the on-peak price corresponds to maximum demand

associated with the load profile, and (2) hourly prices are relatively responsive to demand changes. While these assumptions may be entirely plausible, they need to be explained and defended. (pg 22).

- I think the description of the economic assessment should be spelled out in a little more detail. For example: "The alternative operating options will likely result in not only an increase or decrease in overall capacity and energy production but also a shift in the generation pattern. Thus, economic impacts should include spot market purchases and sales that differ from the base case for each option. In addition, any changes in capital costs due to accelerated or deferred acquisition of new generating resources should be included along with changes in resource operating costs". (pg 4, paragraph 1).
- This process could result in minor errors depending on how may weekend days (especially Sunday) occur in a month. Check to see if monthly water release using this method match with monthly control totals. Simple scaling (# days in a month/7) may be more consistent. (pg 19, paragraph 2).
- Based on the methods document a simple price pattern (e.g., 1 $/MWh for on-peak and 2 $/MWh for on-peak hours) was input into GTMax model. This will result in a very simple flow pattern from GTMax. For example, a double hump pattern will not occur in the winter months and GTMax generation patterns will not be able to reflect super peak load/price hours. Instead the model produces patterns that are flatter than would be expected and Sunday generation is much less than if more representative price patterns are input into the model. On improvement is to put expected prices into GTMax and use the estimated dollar value estimated by the model. (pg 19, paragraph 2).
- First full paragraph. The technique employed by the authors may avoid the criticism that the past does not represent future conditions, but is equally easy to argue that estimates of future prices by a single entity may do an equally poor job as relying on the past. (pg 23).

- Some discussion of the results reported in Table 3 has to be provided here. For example, if annual releases are the same in every year under the dry hydro assumption, why do impacts vary from year to year? (pg 23).
- Please show a table with the assumed energy prices. (pg 24, paragraph 2).
- I think it would also be quite informative to express impacts as a percentage of baseline totals. This would provide much more perspective on the magnitude of the impacts, i.e., $2 million is large number, but it is much more significant when compared to $4 million than when compared to $40 million. (pg 23).

**Do the Analysis effectively Evaluate Economic differences in Options?**

The reviewers understand this analysis is structured to illustrate relative differential impacts of the four options on hydropower economics given the specific baseline (ROD) as a "O" value. As noted, it is not designed to determine the actual value of hydropower for a specific option. That is, the objective of the authors is to determine how each option performs on these economic metrics relative to the current operating procedures, i.e. does it perform better (positive value) or worse (negative value).

The reviewers note that this approach was explicitly stated in the original methods, and is an acceptable approach given the objective for the analysis.

**Specific Reviewer Comments are as follows:**

- To the extent one is interested in the relative impacts of the four options, I do believe the analysis is defensible. When considered from this perspective, relative values are more important than actual values. Because the assumptions made to conduct the analysis are held constant across the options analyzed, this comparability is enhanced. That being said, I have less confidence in the estimated magnitude of the effects of each option. These estimates are highly dependent on such factors as the assumed future price of energy, the cost of capacity expansions, and the relationship between the true opportunity

costs of changes in energy and capacity and the values used in the analysis. Admittedly, I do not see any way around this.

- Whenever one has to project into the future, assumptions have to made and, as other reviewers noted in their assessments of the scope of work, the future is rather uncertain. This is becoming increasing true with respect to energy markets. My point here is that more attention should be focused on differences among alternatives than the magnitude of the estimated costs or benefits of each alternative in the process of drawing conclusions from the analysis.
- What about changes in future resource acquisition and the associated capital and operating costs? Using the market as a preliminary assessment of economic impact is a good screening approach, especially if you also include potential capacity costs or savings. Trying to add the cost or savings of potential changes to future resource acquisitions makes this a much more difficult analysis and, at least until the options are narrowed down, unnecessary. Taking this approach assumes that you have a resource expansion plan or model. (pg 22, paragraph 2).

**Do explicit errors exist and how do they affect the analysis?**

The reviewers determined that no explicit errors seem to exist that would significantly affect the analysis. This analysis is basically a application of models to data sets, with selected assumptions acting generally as constraints on the outcomes.

The models utilized have had accepted, repeated use in these applications. And, generally they are considered properly specified for this type of application.

The type and format of data bases utilized in the analysis are also acceptable to this analysis, with the assumption that they were input without significant transcription error.

The general assumptions are reasonable, and if applied in the models as

proposed, would be expected to produce the relative outcomes presented.

**Specific Reviewer Comments are as Follows:**

- No significant errors were detected in the analysis. All this being said, data bases and specific code for the models used were not presented and therefore not reviewed. There is an expectation that these data were quality checked as referenced.
- The outcomes presented would indicate the models operated effectively with a possible exception occurring in Table 6. Under Option A impacts are positive in 2011. However, according to Table 3, energy impacts are negative under Option A in 2011. This seems counter intuitive.
- At this point, I am confused. I thought that you were going to multiply the difference in generation by the market price to get net cost or benefit of each option. The underlying assumption is that the market is large enough to absorb the surplus or to provide the need. I don't understand how the cost of an accelerated resource acquisition or the benefit of resource deferral is used with the earlier approach. (pg 24, paragraph 1).
- Again, I am confused. Where is the incremental new resource capital cost or the deferred resource savings? I think what you are doing is just fine but it has nothing to do with accelerating or deferring resources. So far you are simply using the market as a surrogate for that process, which is great for this type of study. (pg 25, paragraph 3).
- I wonder if capacity markets can get saturated faster than energy markets? It seems to me that you can always sell surplus energy (well sometimes you may have to spill or shut down a plant) but on the capacity side, as long as a utility has sufficient reserves, it shouldn't have to purchase capacity. You don't purchase market capacity to "displace" your higher cost capacity like you would energy production. I would be interested in some historical data here, that is, how capacity has been sold or purchased in the past. (pg 20, paragraph 1).

- First paragraph in "load following capacity" section. I would think energy represents operating costs and capacity represents construction costs. The authors have it reversed. (pg 18).
- First full paragraph is confusing when considered relative to bottom of page 9. If the generation at all of the other SLCA/IP projects included in each run is held constant, state this explicitly to avoid any confusion. If this is the case, it once again raises the question of possible substitution among generating units that is not accounted for. (pg 19).
- The second paragraph in this section is also rather confusing and needs to be clarified. (pg 19).
- Figure 3 is not correct. It does not visually illustrate the information in Table 11. The figures in Table 11 are totals. Figure 3 refers to annualized data. Also, values along the horizontal axis do not make sense, even it is annualized data being reported. (pg 38).

**Are Bias Included Due to Models, Data and Assumptions Used, and What is Their Effect?**

These types of analysis can be vulnerable to bias form several sources. For example the hydrology evaluated can impact bias. Larger water years will clearly create unequal differentials among the developed options. The authors have mitigated this issue by including analysis of a range of hydrologic conditions, i.e. wet to dry, and have used reasonable protocols for selecting representative traces.

Price differentials of on and off peak power can input bias to the analysis, as well as the actual price levels chosen for the analysis. Obviously higher prices and higher water volumes would favor one option over another. Differing data sets are available to represent prices and price indices. Those selected are specified and reasonable.

Certain assumptions can also input bias into the assessment. This is true of many factors including costs of selected inputs such as purchased power during peak periods. The authors have chosen to use hydrology, prices, and costs etc. that seem to best represent actual conditions. It also

appeared that many inputs and assumptions were developed by a group of stakeholders identified as a Task Team.

**Specific Reviewers Comments are as Follows:**

- The only concern I have in this regard is the assumption that operations at the other dams are unaffected by changes in operations at GCD. As I discuss in other comments this does not allow for any substitution among generating plants that might otherwise occur in response to changes at a single plant (i.e., changes in operations at GCD). I assume the rationale for this assumption is that it greatly reduced the amount of calculations that had to be completed to construct the estimated impacts of each option. This is reasonable given the time constraints imposed on the analysis. One might also argue that this provides a more accurate picture of the impacts of a change in operations at GCD, *ceteris paribus*. Nonetheless, I feel it does introduce a bias into the results that needs to be addressed in the report.
- If operation of the other CRSP plants is allowed to vary in the baseline in response to how GCD is operated, why are they then held constant in the analysis of the GCD options? The possible impacts of this assumption needs to be considered. (pg 11).
- I want to stress that I am not suggesting the authors rerun the analysis with all plants variable. The assumption made here is likely a reflection of the time constraints imposed on the analysis. That being said, the potential biases created by this assumption should be carefully considered in the report. (It would seem to me that running GT Max and allowing only GCD to vary would result in an upper bound estimate of the costs of reduced energy and shifting from peak to off-peak sales). At the same time, the benefits of increased capacity and shifting from off-peak to peak sales would be lower-bound estimates. (pg 8).

- If the dry hydro scenario entails the same maf in each year, why do impacts fluctuate from year to year (as seen in Table 3)? This question is actually answered much later in the report, specifically on page 33, but it needs to be addressed here as well. (pg 12).
- The authors should explain why Flaming Gorge is assumed to operate under steady flows in the base scenario. (pg 13).
- State the assumptions regarding operation of Fontenelle. (pg 14).
- Collbran. Same comment as for Flaming Gorge, i.e., why assume steady flows. Note that if this assumption reflects historical behavior, it might mitigate the effects of modeling GCD in isolation. (pg 14).

**How Could the Analysis be Improved?**

The reviewers propose that more time for planning, analysis and review could have helped the assessment. Even if the outcomes changed little, the confidence of the Task Team in its discussions, selection of methods, assumptions, data bases etc. would have been greater. The analyst's quality checks of data, model runs, evaluation of outputs etc. would have been less frantic and permitted more reflection and discussion with colleagues, which improves analysis.

And, asking reviewers to evaluate complex analysis and assessments in five days and file a final report is not the norm. All this said, all persons involved should be complemented for the professionalism displayed in completing this project in such a short time period.

**Specific Reviewers Comments are as Follows:**

- The most obvious recommendation is to allow more time and resources for these analyses. Doing so would allow the authors to conduct a sensitivity analysis of various assumptions such as the future spot price of power and the costs of capacity expansions. More time would facilitate construction of interval estimates, as opposed to point estimates, of the impacts of a change in dam operations. All else constant, interval estimates are more defensible. I also think it would be worth exploring the affects of allowing operations at all dams to vary

in response to a change in operations at GCED. This would facilitate a more accurate assessment of the affects of a change at GCD on the entire set of SLCA/IP resources.

- The authors need to at least address the plausibility of how water is allocated within a month, possibly by reference to historical weekly and monthly load profiles. (pg 16). The first full paragraph lists a number of items held constant in the analysis, including hourly purchasing prices and capacity replacement costs. Because hourly prices are allowed to vary and capacity replacement costs are based on actual experience of CRSP customers, I'm not sure what is meant by this. I think the authors would be better off simply deleting this statement. (pg 21).
- I also like this approach because it adds more information to the analysis. Calculating a levelized annual cost allows you to perform a tradeoff assessment. There must be a reason for considering these options. If it is to just increase revenue, then choose the option with the highest benefits. But, I am assuming that there may be some non-power costs associated with each option. If those costs can be computed in some way then a cost/benefit analysis can be done. If the consequences affect the environment, it may be difficult to convert impacts into dollars. We certainly have that problem in the Columbia River system. (pg 43, paragraph 1).

# APPENDIX A
# REVIEW OF A STATEMENT OF WORK FOR HYDROPOWER ECONOMIC IMPACTS OF THREE EXPERIMENTAL OPTIONS

# A REVIEW OF THE STATEMENT OF WORK TO EVALUATE THE HYDROPOWER ECONOMIC IMPACTS OF IMPLEMENTING PROPOSED LONG TERM EXPERIMENTAL OPTIONS

**Developed By The**

**GCD AMP Science Advisors Program**

**Reviewers:**

**Dr. Lon Carlson, Illinois State University**

**Dr. John Fazio, Northwest Power & Conservation Council**

**Dr. David Harpman, U. S. BOR**

**Dr. Thomas Vesleka, Argonne National Laboratory**

**SEPTEMBER, 2006**

# A REVIEW OF THE STATEMENT OF WORK TO EVALUATE THE HYDROPOWER ECONOMIC IMPACTS OF IMPLEMENTING PROPOSED LONG TERM EXPERIMENTAL OPTIONS

## INTRODUCTION

The GCD AMP has requested that GCMRC and TWG develop recommendations for a Long Term Experimental Plan. A Science Planning Group (SPG), structured by the GCMRC and TWG developed several experimental plan options over 12 months in 2005/2006, which were reduced to three options for comparison and contrast to the current Record of Decision (ROD) flows for Glen Canyon Dam. This ROD flow regime is identified as a Modified Low Fluctuating Flow(MLFF).

Attributes of the MLFF (baseline condition) and three SPG proposed options, SPG A, B, and C, are presented in Table 1.1. Both flow and non-flow attributes of the options are presented.

To understand more fully how each proposed option might effect CRE resources, the SPG requested two assessments be developed by GCMRC. A Statement of Work (SOW) was developed for each assessment. One SOW presents an assessment of economic impacts on hydropower resources, conducted by WAPA in cooperation with GCMRC. A second SOW presents an assessment of impacts of the three differing options on biophysical and socio-cultural resources, conducted by GCMRC program managers and scientists.

The SPG realized that significant uncertainty would be involved in developing these assessments. As such, the assessments are in major part preliminary.

**DRAFT Table 1.1** Comparison of Base Scenario with Three Experimental Options including Flow and Non-Flow Treatments, and Other Conservation Measures.

| **Flow/Non-Flow Treatment or Conservation Measure** | **BASE Scenario**<br><br>**Modified Low-Fluctuating Flows** | **Option A** | **Option B** | **Option C** |
|---|---|---|---|---|
| Increased Daily Range in Fluctuating Flows | N/A | Yes (daily range increased by from 50% to 66% in winter months and by 25% in summer months) | No | Yes (daily range increased by from 50% to 66% in winter months) |
| Stable Flows | N/A | No | Yes, (tests of 4, 8 and 12 months) | Yes, (Sep.thru Oct.) |
| Beach/Habitat-Building Flows | Possible, but only under Hydrologic Triggers | Yes, as tests under sediment input triggering | Yes, as tests under sediment input triggering | Yes, as tests under sediment input triggering |
| Ramping Rate Studies | N/A | Yes (2X increase in down ramping rate in all months) | No | Yes (2X increase in down ramping rate Nov. thru Jul.) |
| Control of Exotic Warmwater Fish | N/A | Yes, as needed, with R&D starting in 2007 | Yes, as needed, with R&D starting in 2007 | Yes, as needed with R&D starting in 2007 |
| TCD | Yes | Yes | Yes | Yes |
| Humpback Chub Translocation | N/A | Yes | No | Yes |
| HBC Refuge(s) | N/A | Yes | Possibly | Yes |
| HBC Population Augmentation | N/A | Planning Activities | No | Planning Activities |
| Control of Coldwater Fish | N/A | Yes, as needed | Yes, as needed | Yes, as needed |
| Design | N/A | Reverse Titration | Factorial | Forward Titration |
| Mini Experiments | N/A | Yes | Yes | Yes |

NOTE: 1) Cells highlighted in GREEN indicate HBC conservation measures. 2), Mini-experiments are short-term field experiments that do not confound main experimental treatment effects, N/A, Not Applicable.

Assistance in external review of the statements of work (SOW) and assessments was requested of the Science Advisor Executive Secretary. Four reviewers external to the Science Advisors have provided review input to the hydropower SOW, and members of the Science Advisors have presented review input to the bio-physical and socio-cultural SOW.

This report captures the review of the Hydropower SOW (Appendix A).

## REVIEW CHARGE

Eight reviewers were interviewed to conduct this review. Four economists with expertise in hydropower economics were selected for the review as follows.

- Dr. Lon Carlson
- Dr. John Fazio
- Dr. David Harpman
- Dr. Thomas Veselka

Each reviewer was asked to provide review evaluations as per the following two questions.

1. Do the methods, models, assumption, etc. proposed for this hydropower assessment represent a reasonable approach for the analysis?
2. What issues, concerns, opportunities, comment etc. can you provide that might improve upon the approach(s) proposed?

## REPORTING REVIEW RESULTS

These assessments and the reviews have been requested on a very short time schedule. Approximately two week's calendar time are allocated for all four reviews.

The Science Advisor Executive Secretary was provided brief summaries of the reviewer's response to the two questions on hydropower economics, and has drafted them into this report. All points of the reviewers are presented

Following are the responses to the two questions.

**Q.1. Do the methods, models, assumptions etc proposed for this hydropower assessment represent a reasonable approach to the analysis?**

Three of the four reviewers responded to question 1 and the proposed approach, i.e., methods, assumptions, models etc. The three reviewers found that the proposed methods represented a reasonable approach to the assessment.

All four reviewers felt that a more detailed and specific methods write-up should have been provided in the statement of work. Specific comments on question one are as follows:

- I suggest that previous studies be reviewed. Based on what was learned from the past, select, update, and improve upon those assumptions and methods that have worked well in the past. Each aspect of the methodology should be evaluated in terms of its applicability for this study under current and projected conditions. Then tailor the methodology to best meet the needs of the project. New methods and approaches may need to be developed for some aspects of the problem.
- Some of the details regarding the methodology and data will inevitably be highly controversial and should be debated. It is desirable that a consensus be reached on key assumptions before embarking on the analysis. I am not suggesting that the methodology be designed by committee, but a solicitation of suggestions and reactions beyond the peer review panel is highly desirable. This will delay the delivery of the final project, but in the end will produce a better product with a broader acceptance.
- Computing the cost of beach building habitat flows (BBHF) should not be a separate analysis, but instead it should be an integral part of the methodology. One method of accomplishing this and simultaneously addressing hydro variability is to analyze select RiverWare traces (up

to 5) that encompass BBHF and at the same time include a wide range of hydropower conditions.

- The project schedule is overly ambitious. It is suggested that adequate time be given to modelers, researchers, and analysts to produce a high quality product. A very rough guess is that a minimum of three months be allotted for the basic analysis. More would be better. Also, once the draft product has been completed, adequate time must be allotted for revising the analysis and for responding to reviewer comments.
- The proposed methodology correctly distinguishes between two products; namely, capacity and energy. In addition, it attempts to quantify how these products may change over time and the influences of natural random events on the value of the products. However, details regarding how these two products will be evaluated are missing.
- Although the general approach outlined in the methodology is technically very sound, the details of how numerous aspects of the study will be implemented are lacking. These details would be welcome so that reviewers are able to gain a better understanding of how the overall process will be implemented.
- In a very general sense, this project appears to be of a very similar nature to ones that both Western and Reclamation have conducted in the past. Therefore, I don't anticipate that a major revamping of previously used methodologies will be required.
- Given the significant constraints confronting the analysts, I feel the proposed approach is justified and defensible.
- In my opinion the approach is reasonable and should provide valuable data for decision makers.
- I believe that the proposed approaches, as described in the documentation, can lead to the right decision.
- Overall the proposed methodology is technically sound, but many details need to be built upon the basic framework before it is complete.

- Overall, the proposed approach appears to be adequate given the time and resource constraints confronting the analysis.
- The overall methodology for computing economic costs is a standard approach that is well established and generally accepted, and it is appropriate for this study.
- Using ROD restrictions as the baseline is acceptable since it describes current operating rules and regulations. Measuring changes from this current state is an excellent approach.
- I also agree with the general concept of estimating costs over time and computing then as net present value.

**Q.2. What issues, concerns, opportunities, comment etc. can you provide that might improve upon the approach(s) proposed?**

Issues, concerns, opportunities and comments provided by the reviewers covered a wide array of topics. Several dealt with models used, assumptions and time needed for analysis, etc. To assist the reader comments are arranged under several categories. All four reviewers responded to the questions. Following are their review inputs.

**Comments on Models**

- The use of the GT Max Model rather than the Hydro-LP model should produce more reliable results, all else constant. This is because the GT Max Model more accurately reflects the constraints facing Western in terms of location of generation and transmission constraints relative to load on the system.

  The GTmax model operates hourly on a 1-week (168 hour) period. The hydrology generated by Reclamation's RiverWare model is on a monthly time-step. In the interests of transparency, I'd like to see an explanation of how the GTmax model is/will be employed using the monthly RiverWare data. Is the GTmax model run on a "typical week" or 1-week per month basis? If so, what methodology is used to map the results from that typical week to the remainder of the month? Or, is the GTmax model run for each week in the year? If that is the case,

how are the monthly hydrologic outputs from the RiverWare model (release volumes, reservoir elevations) stepped down to each week? A careful explanation of some of these modeling details will (a) enhance the transparency of this work, and, (b) go a long way towards assuring reviewers this analysis was carried out systematically and carefully.

- The RiverWare model has been used for many years. It contains all of the necessary restrictions and regulations regarding the operation of the Colorado River Basin and it is populated with a long historical record of hydrological data. Given its successful track record, it is an excellent choice for simulating long-term reservoir routing for this study.
- Although models are important, input data and the proper use and interpretation of results by analysts who are domain experts is far more important. Reclamation staff are expert users of RiverWare. Likewise, Western staff have extensive experience with GTMax, along with marketing SLCA/IP resources.

**Comments on Prices and Costs**

- Given the proposed input data, the analysis appears to be more of a financial analysis than an economic study. Spot market prices at trading hubs in the WECC and capacity replacement costs obtained from CREDA reflect the financial cost of doing business. It may not be representative of the economic cost of capacity and energy under either the baseline condition or alternative modes of operation.
- The authors are assuming existing market prices are a reasonably good estimate of the opportunity costs of supply options at the margin. It would also appear that it is being assumed that any change in costs of delivering power will not create a significant demand response, i.e., change in the amount of power demanded by end users. To the extent these two assumptions are plausible, the change in the cost of power will provide a reasonably good estimate of the welfare change

experienced by CRSP customers (in the form of either an increase or decrease in consumer surplus), i.e., a reasonable estimate of the economic impacts of each option.

- It is my opinion that prices in open-power markets, such as the one operating in the WECC, do not necessarily reflect the marginal cost of energy or capacity. Bids to sell into the market are not tied to production costs. Rather bids are a reflection of what the market will bear in a transmission constrained system whereby strategic bidding is the norm. These strategies are designed to use a company's market power and weaknesses in the grid to increase corporate profits above those obtained in a perfect marketplace. Corporate behaviors are tempered by political pressures and consumer backlash.
- Current prices may or may not be appropriate to use for the entire 10-year forecast period, since they are closely related to volatile fuel prices. Over the past five years, oil and natural gas prices have gone through dramatic changes. Natural gas prices in this year alone have fluctuated by more than a factor of two. Should the past year be used to represent the next 10?
- The avoided costs (prices) used in the analysis are a critically important input. Their nature and source will have considerable influence on estimates of economic effect, the hourly hydrographs and the overall credibility of the analysis.
- Quite apart from their source, I would suggest careful consideration of the time-step or granularity of the avoided cost (price) data. Our experience is that market transactions don't occur on an hourly basis or sometimes even on a daily basis. The resulting data are typically sparse and this can necessitate the use of some sort of aggregation scheme.
- Since this is a forward looking analysis, I would recommend giving serious consideration to using hourly price forecasts from sources such as the AURORA model. These price sets have the advantage that

they are (a) readily available, (b) transparent in origin, and, (c) replicable.

- If the researchers see some value in using "actual" prices, I draw their attention to the reported market prices collected by Dow Jones Inc. In 2005, these prices are available for major interchanges (such as Palo Verde) on an hourly basis and also in aggregate form on a daily on-peak and daily off-peak basis. The Dow Jones prices have the advantage they are sold to the public, are published daily and their source is well known.
- The avoided cost (price) data used in the analysis will play a considerable role not only in the economic analysis but also in shaping the hourly hydrology produced by the model. Recognizing this, I would want to see a rather substantial narrative and statistical description of these price data. In the interest of transparency and replicability, I would strongly suggest the entire price data set be disclosed in an appendix to the report and/or be made available electronically.
- Will the change in hydro operations affect spot market prices? If so, shouldn't that effect be taken into account?
- My understanding is that a new hourly generation pattern will be created for each of the three test scenarios. The differences in hourly generation (from the base case) will then be priced at the expected spot market rate. For any given hour, additional generation appears as a revenue and a decrease in generation appears as a cost. The net financial impact is the net of the costs and revenues across all hours. This method is quite acceptable for small perterbations in generation (relative to the total generation for the entire power supply). For large changes, it may be necessary to acquire other resources to maintain the adequacy of the power supply. If this situation occurs, it seems to me that the cost savings of shifting hourly hydro generation are not likely great enough to justify the cost of a new resource. However, as discussed above, if these changes can delay the acquisition of a resource or lead to the retirement of an existing resource, then those benefits should be included in the analysis.

- Assumptions regarding prices for both energy and capacity in an economic analysis will have a profound influence on analysis results. There are no clear-cut answers regarding what economic prices were over the past year, what they are in the present or what they will be in the future. Given its importance, I suggest that affected parties agree upon the price methodology and data used for the analysis before it is conducted. Given the importance of price assumptions and its uncertainty, it may be appropriate to analyze several price sets. This may be the only course of action in the event that a price consensus cannot be ascertained. Price uncertainty and volatility is a fact and it should be directly addressed in the analysis.

**Comments on General Approach**

- There are several methods that could potentially be used to select the three hydrological conditions. Is it based on energy or capacity or both? How will maintenance schedules be incorporated into the analysis? Is capacity based on the lowest hydropower condition, a weighted average, or a 10% probability level?
- Generating weekly volume releases by dividing the monthly releases by the number of days is only a good approximation if the monthly fill or draft occurs linearly across the days of the month. Are there periods when the fill or draft occurs more rapidly (or slowly) during some weeks of the month? For example, are there "shoulder" months, i.e. during the snow melt period when the weekly average might be different across the weeks of the month? If so, can some adjustment be made to better capture the releases?
- Is the monthly volume release constrained or can the LP also increase or decrease the monthly volume to maximize revenues or to minimize cost? In other words, does the LP optimize the operation over a single week or can it optimize over several months? It appears that the optimization is only for the week. If so, this is not a problem for the

analysis, however, other gains in revenue may be possible by shifting water from month to month as prices vary.

- My understanding is that the study will cover a ten year period. It was not clear to me what kind of load growth would occur over this period. Assuming that the power supply is currently adequate, how will the additional load growth be met? Are new resources acquired over the ten year period? Would a low growth rate or a high growth rate affect the results of this analysis? Can the additional flexibility in the hydroelectric operation defer the acquisition of new resources. If so, then the deferral savings should be a part of the analysis.
- How do future uncertainties affect this study? For example, you are planning to analyze each scenario over a dry, wet and average water condition. Will you weigh the results to indicate that average conditions are more likely to occur than the dry and wet conditions? Are you examining uncertainties in electricity prices? Are there price scenarios that may change the outcome of the analysis? New adequacy requirements resulting from the recently passed Energy Bill may alter the resource mix of neighboring regions and thus may affect price scenarios. I understand that it may be difficult to assess what may fall out of that process but it may be wise to identify types of price scenarios that would be undesireable relative to the proposed operations.
- Will there be any reduction in greenhouse gas emissions related to any of the scenarios? If so, can these benefits be converted into monetary values and added to the assessment? Will the benefits increase substantially if a carbon tax were enacted?
- Regarding the economic analysis, I am assuming the objective is to estimate, for each of the proposed alternatives, the increase or decrease in the net amount paid for power by CRSP long-term customers relative to the baseline. This change in costs is the result of a decrease or increase in Western's ability to generate power for

delivery to customers. However, it is not entirely clear how the baseline is valued. I'm assuming prices stipulated in existing long-term firm contracts will be used. My understanding is that for each experimental option, the GT Max Model will be used to estimate the cost-minimizing mix of supply options that will satisfy each customer's demands. Changes in the supply mix will then be valued using either replacement costs or avoided costs, which in turn will be based on current market prices.

- I strongly recommend, that the authors carefully lay out the procedures and supporting assumptions they are making at the beginning of the analysis and consider the plausibility of the assumptions being made. In addition, they should explicitly consider the sensitivity of their results to the underlying assumptions. In particular, they should explain, qualitatively, how deviations from the underlying assumptions, e.g., greater than expected demand elasticity on the part of end users, would be expected to affect the values of the estimated impacts.
- Although this document contains the phrase "scope of work" in the title, it is very brief and lacks most of the analysis and methodology details I was expecting. The inclusion of multiple additional supporting documents is only semi-helpful.

**Characterization of TCDs**

- The scope of work alludes to an investigation of the effects of installing and operating temperature control devices (TCDs) at Glen Canyon Dam. Such an analysis would be a fairly ambitious undertaking, independent of the other tasks described. Aside from any impacts during the construction of these devices, the operation of TCDs can effect the generation of hydropower through the following mechanisms:
  - head loss
  - water density
  - electro-mechanical efficiency

- Installation of the TCDs will also require a greater minimum submergence depth (30 feet). This will need to be reflected in the monthly hydrologic modeling on which the analysis is based. Conspicuously absent from this document is any narrative describing how an assessment of the proposed TCDs might be undertaken. Reclamation has recently completed a detailed assessment of the impacts of installing and operating TCDs at Glen Canyon Dam.

**Characterization of Turbine Replacements**

- The turbine runners at Glen Canyon Dam are scheduled for replacement. The scheduled replacement of the turbine runners at Glen Canyon Dam will increase hydropower generation from 1 to 7% (Brooks 2005). Relative to the existing runners, the new runners will result in a differential increase in generation which varies in a relatively complex manner with lake elevation and release. The GC_CAP model was developed to facilitate quick and easy explorations of the effects of the new turbine runners. Calculations using the GC_CAP model, using a lake elevation of 3,600 feet and a release of 20,000 cfs, show an increase of 49.84 MW will result when the installation of the new runners is complete.

**Characterization of Reserves**

- Depending on the season and the reserve-sharing arrangements currently in place, Glen Canyon is used to provide some amount of system reserves. As a reviewer of the analysis product, I would want to know how reserves were accommodated in the analysis. Further, I would think it would be beneficial to have some understanding of where these reserves are furnished and at what cost when "dry" hydrologic conditions preclude their provision at Glen Canyon Dam or other CRSP facilities.

**Multiple Hydrologic Conditions**

- As stated in the narrative, the analysis will be undertaken on three hydrologic traces. This will result in a better understanding of the

interactions of hydrology and the experimental design. In my view, this will yield a more robust and more defensible analysis which will presumably lead to a more informed decision-making process.

To allow for future replication of this work by other researchers, I suggest the detailed monthly hydrology for each hydrology and each case (monthly releases and reservoir elevations) used in this analysis be published in an appendix and/or made available electronically.

**BHBFs and Monthly Release Volumes.**

- The scope of work (last bullet) describes the analysis of beach habitat building flows (BHBFs). I infer from the last sentence the analysis will encompass each of the 3 hydrologic conditions resulting in 9 model runs. Unless the base cases correspond exactly with cases that have already been modeled, an accurate assessment of the cost of a BHBF will require the modeling of a base case for each of the 3 hydrologic conditions, bringing the total effort to 12 runs.
- As acknowledged by the investigators, implementation of a BHBF is likely to entail a difference in monthly water volumes across the entire water year. Consequently, it is necessary to model not only the period of time when the BHBF takes place, but the entire water year.

**Baseline Case**

- In the next to last bullet, there is some language about reporting differences from the baseline. While the language is terse and possibly I misinterpreted the meaning, I was unsure if that meant the baseline results would not be reported? Hopefully, that is not the case. I would suggest reporting the results of the base case, each of the change cases, and the differences between them. As an aide to interpretation, I would suggest that these differences also be furnished as percentage differences.

# APPENDIX A
# THE HYDROPOWER ECONOMIC IMPACT STATEMENT OF WORK

**Project 10.R1.07: A Scope of Work to Evaluate Economic Impacts of Implementing Proposed Long-Term Experimental Options on the Economics of Hydropower Operations.**

**Start Date:** August 20 2006

**End Date:** November 22 2006

**Principal Investigator:**

Western Area Power Administration and GCMRC

**Geographic Scope:**

Economic impact analysis estimate for Colorado River Storage Project (CRSP) hydropower generation for three proposed long-term experimental option/s.

**Project Goals/Tasks:**

The goal of this research project is to estimate the economic impacts to CRSP hydropower generation from implementation of three differing long-term experimental options identified in the attached table.

**Need for Project:**

The Science Planning Group (SPG) of the Glen Canyon Dam Adaptive Management Program (AMP) has proposed three potential new long term experimental options with flow and non-flow elements. These proposed long-term experimental options are expected to result in differing impacts on downstream physical, biological and socio-economic resources of the Colorado River Ecosystem. The Adaptive Management Work Group (AMWG) and Technical Work Group (TWG) have requested analysis of the proposed long-term experimental options impacts on Colorado River ecosystem resources to assist in the process of making recommendation(s) to the Secretary of the Department of the Interior regarding long-term experimentation. One of the requested analyses is impacts to hydropower resources.

**Strategic Science Question:**

1 – 3. What are the estimated hydropower economic impacts associated with each of the proposed long-term experimental options?

**Link/relationship to Other Projects:**

- This project is directly linked to a comprehensive evaluation of potential resource impacts associated with proposed long-term experimental options identified in the following table.

**Information Needs Addressed:**

This project responds to several Research Information Needs (RINs) that have been articulated in the 2003 version of the AMP Strategic Plan, including:

- RIN 10.1.1: What would be the effects on the CRE and marketable capacity and energy of increasing the daily fluctuation limit?

- RIN 10.1.2: What would be the effects on the CRE and marketable capacity and energy of increasing the upramp and downramp limit?

- RIN 10.1.5: How do power-marketing contract provisions affect GCD releases?

**General Methods of the Analyses**

**Assumptions**
Specific assumptions exist regarding several factors associated with each option. The assumptions are specified in the attached table of options.

**Methods**

**Task 1. Describe the flow regime associated with each proposed long-term experimental option (BR/ WAPA).** Reclamation will provide computed monthly volumes for each option. Western would then produce data tables associated with the daily hydrograph for each option based on these monthly volumes.

**Task 2. Establish a project review team (GCMRC).** GCMRC will contract the services of independent reviewers to review this Scope of Work, the analysis, modeling assumptions and methodologies, final report and recommendations and ensure the results are consistent with the Scope of Work. Peer review will be coordinated by the Science Advisors Executive Secretary.

**Task 3. Evaluate the estimated economics of hydropower impacts related to changes in hydropower production at Glen Canyon Dam for each of the long-term experimental options being evaluated (WAPA).** The analysis methods are as follows:

- The assessment evaluates four conditions , a baseline and three experimental options as specified in the attached table of options. Calculate the estimated economic impacts on CRSP long-term, electrical power customers resulting from each proposed experimental option relative to a baseline condition.
- The baseline condition will be the current operating criteria for Glen Canyon Dam (GCD) as identified in the 1996 Record of Decision (ROD).
- The baseline condition and the three experimental options will be expressed using GCD release information based on three hydrological conditions: dry, median (most probable) and wet.

- Each hydrological condition will be modeled by USBR for a 10-year period beginning in WY 07. Data developed by USBR as input information for the economic analysis will be GCD monthly water release and end-of-month lake elevation.
- Using the GT Max model and USBR monthly volume and elevation input values, develop hourly generation for each of the proposed long-term experimental options proposed flow regimes.
- Compare the GT Max output values for the proposed long-term experimental option flow regimes against the baseline and evaluate the economic impacts of each of these proposed long-term experimental options against the baseline.
- The valuation of the baseline and hourly differences between the baseline and each of the change cases will be based on replacement cost or costs avoided. This is a simplifying assumption with respect to an economic analysis. Current market prices for electrical energy will be used to represent replacement cost.
- Long-term firm capacity differences that would occur as a result of changes in GCD operating parameters for each option will be valued at replacement cost or avoided cost (same comments apply here as in the previous bullet.
- Since it is anticipated that a proposed long-term experimental option will be implemented over a period of years, it is assumed that WAPA will make purchases or sales under existing contract conditions.
- Replacement cost information will be provided by members of the Colorado River Energy Distributors Association (CREDA).
- The result of the economic analysis for each option will be reported in differences from the baseline. These will be reported both in terms of a net present value and as an annualized average cost/benefit.
- A separate calculation will be done regarding Beach Habitat Building Flows (BHBF). USBR will provide WAPA with the monthly water volumes related to with and without BHBF events. This will be done using the most probable hydrological release condition. It will be evaluated separately for three times in the year: fall, winter and spring. Each of these will be calculated for each option (this is a total of nine estimates of the cost of BHBF).

**Task 4. Draft Project Report (WAPA/GCMRC)**

**A draft project report will be prepared by WAPA and GCMRC to present the results of the assessment.** At a minimum the following sections are to be developed in the report.

I. Introduction and purpose
   - A. Context of the analysis
   - B. Purpose of the analysis

II. Objectives
   - A. Specific objective sought in the analysis, questions, etc.

III. Methods for Assessment
   - A. Assumption for analysis
   - B. Analysis methods used

IV. Results and Conclusions
   - A. Results: Comparative analysis of three experimental options with a baseline option (ROD).
   - B. Conclusions: Specification of how differing options increase or decrease power values from ROD values and implication to WAPA and CRSP.

**Task 5. Peer Review (SA). A peer review panel is established to review the statement of work and the draft WAPA/GCMRC report on the assessment.** The panel members are as follows:

- Lon Carlson; Northern Illinois State University
- Timothy Fazio; Northwest Fisheries Science Center
- Dave Harpman; US BOR, Technical Center
- Tom Valeska; Argonne National Laboratory

Two reviews will be developed by the panel as follows:

Scope of Work: The goal of this review is to determine if the objectives of the SOW will be met by the assumptions and methods specified.

Hydropower Assessment Report: The goal of this review is to determine if the objectives of the analysis are met. The review will evaluate appropriate application of assumptions, models, data, etc. to obtain the outcomes reported. The review will also evaluate if the conclusions drawn are reasonable given the assumptions and analysis.

**Task 6. Outcomes; Final Report and Presentation to TWG (WAPA/GCMRC)** Two outcomes are specified, a final written report on results and conclusions, and a formal presentation to the TWG and AMWG. Note that modifications to options by the SPG, TWG or AMWG may be requested. If that occurs, the analysis will be respecified accordingly and may result in a modification and delay of the draft report, final report presentation to TWG.

**Schedule**

The schedule for this project is as follows:

1. Review panel established; 7/28/06
2. Scope of Work complete; 8/20/06
3. Experimental options, assumptions fully specified; 8/20/06
4. Science panel review of SOW; 8/25/06
5. WAPA/GCMRC complete draft report; 9/22/06
6. Science panel review of draft report; 9/29/06
7. Complete final report and presentation to TWG; 10/10/06

**Budget:**

| R1.06 | |
|---|---|
| **Economic Implications of Alternative Experimental Flows (FY06)** | |
| | **scal Year 2007** |
| / USGS Salaries | |
| Project Related Travel/Training | - |
| Operations/ Supplies | - |
| Equipment Purchase / Replacement | - |
| istics Support | - |
| SGS Contract Science Labor (17% Burden Rate) | $26,000 |
| ve / Interagency Agreements (6% Burden Rate) | - |
| **ub-total** | $26,000 |
| omer Burden (Combined 6 and 17% rates) | $3,600 |
| **otal (Gross)** | $30,100 |
| utsourced (Out of USGS) | 100% |
| | - |

1. **Table 1.** Long Term Experimental Options being evaluated by SPG.

| Option | No Action | Option SPG-A | Option SPG-B | Option SPG-C (Proposed) |
|---|---|---|---|---|
| Flow regime | MLFF (ROD flows) | Increased fluctuating flows in 10 months; ecologically stable flows in September and October | Stable Flow Testing initially in summer/fall (4 mos.), eventually moving toward seasonally adjusted steady flows in all months, | MLFF with stable flows in September and October and increased fluctuating flows in 3 winter months |
| Implement Expanded Fluctuating Flows Testing | All releases within ROD operating constraints) | Yes, (all months except in September and October) | None (all releases within ROD operating constraints) | Releases within ROD operating constraints in all months except Dec-Feb (increased fluctuations) |
| Stable Flows | None | Yes, Sep.-Oct. only; includes tests to define ecologically steady flow | Yes, (4-12 months each year) | Yes, September and October only; includes tests to define ecologically steady flow |
| Beach/Habitat-Building Flow (41,000 to 45,000 cfs, 1-3 days, in spring) | Yes in April following sand enrichment from major tributaries | Yes, in April following sand enrichment from major tributaries | Yes, in Jan-April following sand enrichment from major tributaries & consideration of native fish impacts | Yes in April following sand enrichment from major tributaries |
| Ramping Rate Studies | Possibly so long as they are within ROD | Yes (November – August) | None (ROD ramping rates) | Yes |
| Tests of Exotic Fish Control, (Warmwater & Coldwater) | Possible | Yes, as needed | Yes, as needed | Yes |
| Build & Test (Selective Withdrawal Structure) | Possible | Yes | Yes | yes |
| HBC Translocation | Possible | Yes | Depends on Further Analysis | Yes |
| HBC Refuge(s) | Possible | Yes | Depends on Further Analysis | Yes |
| HBC Population Augmentation Planning | Possible | Planning efforts toward implementation as | No activities toward this action | Planning efforts toward Implementation (as needed) |

| | | | | |
|---|---|---|---|---|
| | | needed | | |
| Experimental Design | Forward titration/block design | Forward titration in phase 1 | Forward titration—steady flows implemented incrementally in 4 month blocks over 6 years | Implemented in 3 5-year increments with flow regimes remaining constant in phase 1 and 2; implementation and testing of TCD in phase 2; evaluation to determine flows in phase 3 |